Corrected
ATTACHMENT 21

Appendix B1

wLFRM Model Documentation Report

Lower Fox River/Green Bay Remedial Investigation and Feasibility Study

Development and Application of a PCB Transport Model for the Lower Fox River

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1.0 SUMMARY

This report is provided in support of U.S. Environmental Protection Agency (USEPA) Cooperative Agreement #V985769-01 with the Wisconsin Department of Natural Resources (WDNR). The water quality model presented in this report is one of several tools to examine contaminant transport in the Lower Fox River. The primary contaminant of concern was polychlorinated biphenyls (PCBs). The goal of this effort was to provide estimates of: 1) PCB export to Green Bay, and 2) biotic PCB exposure in the river.

Efforts to assess PCB transport in the Lower Fox River using water quality models have been extensive. The model developed as part of RI/FS efforts is the result of continued assessments of Lower Fox River water quality model performance and represents the fourth generation of model development. This fourth generation model is identified as the "whole" Lower Fox River model (wLFRM). The wLFRM describes PCB transport in all 39 miles of the Lower Fox River from Lake Winnebago to the river mouth at Green Bay in a single spatial domain. The state variables simulated were suspended solids (three classes) and total PCBs. Short-term and long-term simulations were conducted. The short-term simulation period was 1989-95 and was used for model calibration. The long-term simulation period was 100 years and was used to project future PCB export to Green Bay and exposure trends in the river. Numerical simulations were performed using the USEPA IPX Version 2.7.4 water quality modeling framework.

The wLFRM was developed from the results of the Model Evaluation Workgroup (MEW) that was formed in collaboration with the Fox River Group (FRG) of Companies on the basis of a January 31, 1997 Agreement. The MEW prepared a series of technical reports that define values for the most critical model features such as flows, loads, initial conditions, boundary conditions, and sediment transport. The MEW reports represent the most detailed description possible of pertinent river conditions using existing information and provided the majority of the information necessary for model development. The FRG also initiated a peer review of model performance that was managed by the American Geological Institute (AGI, 2000). To the greatest extent practical, peer review panel recommendations were integrated into wLFRM development efforts.

Model performance was evaluated according to the metrics identified in Technical Memorandum 1 (LTI and WDNR, 1998). When making comparisons, it is important to understand how the observations and model results used to assess model performance were interpreted. Successful application of a metric depends on how closely the interpretation of field data represent the true condition of the river as well as whether the spatial and temporal scale of observations and model results are comparable. For the water column, interpretation of observations was straightforward and permitted direct comparison of observed values and model results. However, interpretation of sediment observations was not straightforward. Representative sediment conditions applicable to broad areas are difficult to accurately determine from observations at individual points or along a line. For the water column, relative differences between observed solids and PCB concentrations and model results were within ±30%. Relative differences for the sediment column were much larger. Nonetheless, the wLFRM was able to capture the trend and magnitude

of inferred PCB concentration changes over time in surface sediments. Given these considerations, the wLFRM calibration was judged to adequately meet the criteria identified in Technical Memorandum 1.

Note that, as demonstrated by the results of field sampling efforts, the only significant source of PCBs to Lower Fox River is the river sediments. Further, PCB concentrations in river water are essentially zero at the upstream boundary with Lake Winnebago and increase to an average of more than 50 ng/L at the river mouth. The wLFRM reproduces these critical site features: 1) the origin of PCB from sediments; and 2) the trend and magnitude of PCB concentrations in the water column. In consideration of model performance strengths and limitations, the wLFRM calibration was considered to provide a reasonable description of PCB concentrations and export in the Lower Fox River on a year-by-year, reach-by-reach basis. The best use of this model may therefore be as an indicator of the relative trend and magnitude of PCBs concentrations and export. In this context, year-by-year, reach-by-reach resolution of this model was considered sufficient to meet overall project goals.

The wLFRM was used to prepare long-term projections of the trend and magnitude of PCB concentrations in the river for a range of different sediment management cases. Over time, water column and sediment PCB concentrations decrease for all cases. This is an expected result since, without significant PCB inputs from point source discharges, the surrounding watershed, or the atmosphere, the PCB inventory of river surface sediments will decrease by dilution and dispersal.

Relative differences in forecast simulation results are clearly present. Compared to all other cases, the no action simulation has the greatest PCB concentrations and cumulative export to Green Bay over time. Note that as action levels decrease, the differences between simulation results for each action level increase relative to the no action simulation. The level of relative reduction is a reflection of decreased sediment PCB initial conditions for each case. Also note that at the lowest action levels, which represent larger sediment management efforts, the relative decrease in PCB concentration and export between cases becomes smaller. For example, the difference between the 250 and 125 µg/kg cases is smaller than the difference between the 500 and 250 µg/kg cases. The relative difference between the 250 and 125 µg/kg cases is comparatively small since the average reduction in initial surface sediment PCB concentrations is small.

Table 4-4. Frequency distribution comparisons for the water column.

Constituent	*Relative Difference Between Mean Observed and Modeled Concentrations by Monitoring Site*						
	Appleton	*Kaukauna*	*Little Rapids*	*DePere*	*River Mouth*	*Average (All Sites)*	*Average (4 sites)*[13]
TSS	-19.5%	-13.5%	-8.6%	-5.8%	-32.4%	-16.0%	-17.8%
PCBs	-40.5%	-31.0%	-73.3%	-31.0%	-16.8%	-38.5%	-29.8%

14. Note that for solids there are many different kinds of measurements from which comparisons may be developed. For simplicity, frequency distribution comparisons for solids are based on the solids measurements associated with PCB observations (generally noted as EWI TSS). Comparisons for total PCBs are presented in Figures 4-15 through 4-24.

In general, the time series comparisons indicate that the model results agree with the trend and magnitude of the observations. However, the results are generally less than observed values indicating that the model has a low bias. With the exception of PCBs at the Little Rapids monitoring site, the frequency distribution comparisons also indicate that agreement between results and observations is generally good. However, the results are generally less than observed values and again indicate that the model has a low bias. Note that model results are also less than the maximum observed values. Model results are nonetheless in satisfactory agreement with observed values and meet the ±30% quality criteria established in TM1 based on frequency distribution comparisons. A summary of calibration simulation performance for solids and PCBs in the water column based on frequency distribution comparisons is presented in Table 4-4.

4.3.1.2 Point-in-Time/Cumulative Performance Comparisons

A series of different point-in-time and cumulative performance comparisons of observations and model results can be developed. As an example, for each date where solids or PCB observations exist it is possible to develop point-in-time comparisons of observations and results along the longitudinal axis of the river on that date (e.g. concentration versus distance from Lake Winnebago). However, at least for PCBs, observations on the same date often do not exist for all monitoring stations. Given the considerable distances (miles) between river monitoring stations, the nature and extent of concentration differences over any distance may also be difficult to assess. Therefore, given the extent of observations, cumulative performance comparisons were considered to provide a better basis for evaluating model performance.

For simplicity, cumulative performance comparisons were developed for the river mouth monitoring station at Green Bay. Based on flow and PCB concentration observations at the river mouth, the USGS estimated PCB export to Green Bay to be 241 kg in 1994 and 190 kg in 1995 (USGS, 1999). The total PCB export for the 1994-1995 period was 431 kg. Model results for

[13] Average of four sites: Appleton, Kaukauna, DePere, and the river mouth.

6.0 CONCLUSIONS

The following conclusions regarding wLFRM development and application are offered:

1. The wLFRM was developed from the results of the Model Evaluation Workgroup (MEW) that was formed in collaboration with the Fox River Group (FRG) of Companies on the basis of a January 31, 1997 Agreement. The MEW prepared a series of technical reports that define values for the most critical model features such as flows, loads, initial conditions, boundary conditions, and sediment transport. The MEW reports listed in Table 2-1 represent the most detailed description possible of pertinent river conditions using existing data and provided the majority of the information necessary for model development.

2. The FRG initiated a peer review of model performance that was managed by the American Geological Institute. To the greatest extent practical, peer review panel recommendations were integrated into wLFRM development efforts.

3. The wLFRM describes PCB transport in all 39 miles of the Lower Fox River from Lake Winnebago to the river mouth at Green Bay in a single spatial domain. All simulations were performed using the IPX 2.7.4 framework (Velleux et al. 2000). Solids were treated as three state variables throughout the model spatial domain. This approach is consistent with peer review recommendations.

4. Model performance was evaluated according to the metrics identified in Technical Memorandum 1 (LTI and WDNR, 1998), a MEW work product. When making comparisons, it is important to understand how the observations and model results used to assess model performance were interpreted. Successful application of a metric depends on how closely the interpretation of field data represent the true condition of the river as well as whether the spatial and temporal scale of observations and model results are comparable. For the water column, interpretation of observations was straightforward and permitted direct comparison of observed values and model results. However, interpretation of sediment observations was not straightforward. Representative sediment conditions applicable to broad areas were difficult to accurately determine from observations at individual points or along a line. For the water column, the relative difference between observed solids and PCB concentrations and model results was within ±30%. Relative differences for the sediment column were much larger. Nonetheless, the wLFRM was able to capture the trend and magnitude of inferred PCB concentration changes over time in surface sediments. Given these considerations, the wLFRM calibration was judged to adequately meet the criteria identified in Technical Memorandum 1.

5. The most critical features of the site are the origin of PCBs from river sediments and the general trend and magnitude of PCB concentrations in river water. As demonstrated by the results of field sampling efforts, the only significant present-day source of PCBs to Lower Fox River is the river sediments. PCB concentrations in river water are essentially zero at the upstream boundary with Lake Winnebago and increase to an average of more than 50 ng/L at